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In re application of: **ATWATER et. al**
Application Serial No.: **10/684,063**
Application Filed: **October 8, 2003**
Attorney Docket No.: **CECOM 5465**
For: **MANGANESE, BISMUTH MIXED METAL OXIDE CATHODE FOR RECHARGEABLE LITHIUM ELECTROCHEMICAL SYSTEMS**

AMENDMENTS TO THE CLAIMS

Madame:

In accordance with the enclosed Remarks, please amend the claims in the above-identified application as follows:

1. (Canceled) A cathode material for a lithium electrochemical system, comprising:

a positive, active manganese bismuth mixed metal oxide compound having the general formula $MnO_y (Bi_2O_3)_x$, where said subscript x is greater than 0.05 and less than 0.25 and said subscript y is about 2.0;

said compound having a reduced charge transfer impedance due to a catalytic reaction causing said cathode material to prevent an overcharge and a phase change; and

said compound remains reversible against a lithium compound in said lithium electrochemical system.

2. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 1, further comprising said compound resulting from a solid-state reaction between manganese dioxide and bismuth.

3. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 2, further comprising said cathode material providing an initial specific capacity of about

150 mAhrs/g.

4. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 3, further comprising said cathode material providing a sustained specific capacity of about 120 mAhrs/g

5. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 4, further comprising said subscript x being greater than 0.05 and less than 0.135.

6. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 5, further comprising said compound being $MnO_2 (Bi_2O_3)_{0.12}$.

7. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 6, further comprising said compound being fully reversible.

8. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 7, further comprising said system being rechargeable.

9. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 8, further comprising:

said initial specific capacity being maintained with 2/3 of an initial discharge capacity through 100 cycles;

said system having a coulombic efficiency greater than 97 per cent; and

said system having a 95 per cent energy efficient charge.

10. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 9, further comprising:

said solid-state reaction being $Li + MnO_y (Bi_2O_3)_x = Li_z MnO_y (Bi_2O_3)_x$, where said subscript z approaches 0.0 in said solid-state reaction;

an overcharge protection is avoided; and

a charge transfer catalytic behavior is provided allowing said cathode material to be fully reversible.

11. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 1, further comprising said system being a lithium ion electrochemical system.

12. (Canceled) The cathode material for the lithium electrochemical system, as recited in claim 1, further comprising said compound resulting from a solid-state reaction between manganese dioxide, and a bismuth compound.

13. (Canceled) A manganese bismuth mixed metal oxide cathode for a lithium electrochemical system, comprising:

a positive, active manganese bismuth mixed metal oxide compound having the general formula $MnO_y(Bi_2O_3)_x$, where said subscript x is greater than 0.05 and less than 0.25 and said subscript y is about 2.0;

said compound having a reduced charge transfer impedance due to a catalytic reaction causing said cathode to prevent an overcharge and a phase change;

a conductive carbon and a binder being mixed with said compound; and

said cathode remains reversible against a lithium compound in said lithium electrochemical system.

14. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 13, further comprising said compound resulting from a solid-state reaction between manganese dioxide and bismuth.

15. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 14, further comprising said cathode material providing an initial specific capacity of about 150 mAhrs/g.

16. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 15, further comprising said cathode providing a sustained specific capacity of about 120 mAhrs/g.

17. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 16, further comprising said subscript x being greater than 0.05 and less than 0.135.

18. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 17, further comprising said compound being $MnO_2 (Bi_2O_3)_{0.12}$.

19. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 18, further comprising said compound being fully reversible.

20. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 19, further comprising said system being rechargeable.

21. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 20, further comprising:

said initial specific capacity being maintained with 2/3 of an initial discharge capacity through 100 cycles;

said system having a coulombic efficiency greater than 97 per cent; and

said system having a 95 per cent energy efficient charge.

22. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium

electrochemical system, as recited in claim 21, further comprising:

said solid-state reaction being Li + $MnO_y (Bi_2O_3)_x = Li_z MnO_y (Bi_2O_3)_x$, where said subscript z approaches 0.0 in the reaction;

an overcharge protection is avoided; and

a charge transfer catalytic behavior is provided allowing said cathode material to be fully reversible.

23. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 13, further comprising said system being a lithium ion electrochemical system.

24. (Canceled) The manganese bismuth mixed metal oxide cathode for the lithium electrochemical system, as recited in claim 13, further comprising said compound resulting from a solid-state reaction between manganese dioxide, and a bismuth compound.

25. (Canceled) A lithium electrochemical system, comprising:

an lithium anode;

a metal oxide cathode;

an organic electrolyte;

a positive, active manganese bismuth mixed metal oxide compound having the general formula $MnO_y (Bi_2O_3)_x$, where said subscript x is greater than 0.05 and less than 0.25 and said subscript y is about 2.0;

said compound having a reduced charge transfer impedance due to a catalytic reaction causing said cathode to prevent an overcharge and prevent a phase change;

a conductive carbon and a binder being mixed with said compound; and

said compound remains reversible against a lithium compound in said lithium electrochemical system.

26. (Canceled) The lithium electrochemical system, as recited in claim 25, further

comprising said compound resulting from a solid-state reaction between manganese dioxide, and bismuth.

27. (Canceled) The lithium electrochemical system, as recited in claim 26, further comprising aid metal oxide cathode providing an initial specific capacity of about 150 mAhrs/g.

28. (Canceled) The lithium electrochemical system, as recited in claim 27, further comprising said metal oxide cathode providing a sustained specific capacity of about 120 mAhrs/g

29. (Canceled) The lithium electrochemical system, as recited in claim 28, further comprising said comprising said subscript x being greater than 0.05 and less than 0.135.

30. (Canceled) The lithium electrochemical system, as recited in claim 29, further comprising said compound being $MnO_2 (Bi_2O_3)_{0.12}$.

31. (Canceled) The lithium electrochemical system, as recited in claim 30, further comprising said compound being fully reversible.

32. (Canceled) The lithium electrochemical system, as recited in claim 31, further comprising said system being a lithium battery.

33. (Canceled) The lithium electrochemical system, as recited in claim 32, further comprising said system being a rechargeable lithium battery.

34. (Canceled) The lithium electrochemical system, as recited in claim 33, further comprising:

said initial specific capacity being maintained with 2/3 of an initial discharge capacity through 100 cycles;

said system having a coulombic efficiency greater than 97 per cent; and

said system having a 95 per cent energy efficient charge.

35. (Canceled) The lithium electrochemical system, as recited in claim 34, further comprising:

said solid-state reaction being $Li + MnO_y (Bi_2O_3)_x = Li_z MnO_y (Bi_2O_3)_x$, where said subscript z approaches 0.0 in the reaction;

an overcharge protection is avoided; and

a charge transfer catalytic behavior is provided allowing said cathode material to be fully reversible.

36. (Canceled) The lithium electrochemical system, as recited in claim 35, further comprising said system being a lithium ion electrochemical system.

37. (Canceled) The lithium electrochemical system, as recited in claim 25, further comprising said lithium anode being composed of a lithium metal.

38. (Canceled) The lithium electrochemical system, as recited in claim 25, further comprising said lithium anode being a lithium ion.

39. (Canceled) The lithium electrochemical system, as recited in claim 25, further comprising said compound resulting from a solid-state reaction between manganese dioxide, and a bismuth compound.

40. (Canceled) A rechargeable lithium battery, comprising:

an lithium anode;

a metal oxide cathode;

an organic electrolyte;

a positive, active manganese bismuth mixed metal oxide compound having the general formula $MnO_y(Bi_2O_3)_x$, where said subscript x is greater than 0.05 and less than 0.25 and said subscript y is about 2.0;

said compound having a reduced charge transfer impedance due to a catalytic reaction causing said cathode to prevent an overcharge and prevent a phase change;

a conductive carbon and a binder being mixed with said compound; and

said compound remains reversible against a lithium compound in said lithium electrochemical system.

41. (Canceled) The rechargeable lithium battery, as recited in claim 40, further comprising said compound resulting from a solid-state reaction between manganese dioxide, and bismuth.

42. (Canceled) The rechargeable lithium battery, as recited in claim 41, further comprising said metal oxide cathode providing an initial specific capacity of about 150 mAhrs/g.

43. (Canceled) The rechargeable lithium battery, as recited in claim 42, further comprising said metal oxide cathode providing a sustained specific capacity of about 120 mAhrs/g

44. (Canceled) The rechargeable lithium battery, as recited in claim 43, further comprising said subscript x being greater than 0.05 and less than 0.135.

45. (Canceled) The rechargeable lithium battery, as recited in claim 44, further comprising said compound being $MnO_2(Bi_2O_3)_{0.12}$.

46. (Canceled) The rechargeable lithium battery, as recited in claim 45, further comprising said compound being fully reversible.

47. (Canceled) The rechargeable lithium battery, as recited in claim 46, further

comprising:

said initial specific capacity being maintained with 2/3 of an initial discharge capacity through 100 cycles;

said system having a coulombic efficiency greater than 97 per cent; and

said system having a 95 per cent energy efficient charge.

48. (Canceled) The rechargeable lithium battery, as recited in claim 47, further comprising:

said solid-state reaction being Li + $MnO_y (Bi_2O_3)_x = Li_z MnO_y (Bi_2O_3)_x$, where said subscript z approaches 0.0 in the reaction;

an overcharge protection is avoided; and

a charge transfer catalytic behavior is provided allowing said cathode material to be fully reversible.

49. (Canceled) The rechargeable lithium battery, as recited in claim 40, further comprising said lithium anode being composed of a lithium metal.

50. (Canceled) The rechargeable lithium battery, as recited in claim 40, further comprising said lithium anode being a lithium ion.

51. (Canceled) The rechargeable lithium battery, as recited in claim 40, further comprising said lithium battery being a lithium ion battery.

52. (Canceled) The rechargeable lithium battery, as recited in claim 40, further comprising said compound resulting from a solid-state reaction between manganese dioxide, and a bismuth compound.

53. (Currently Amended) A method of making a manganese mixed metal oxide cathode ~~for a lithium electrochemical system~~, comprising the steps of:

selecting a bismuth compound from the group of bismuth compounds consisting of Bi_2O_3, $Bi(OH)_3$ or Bi metal;

mixing said bismuth compound with MnO_2;

heating said mixture in an annealing oven between 400°C and 600°C for at least 72 hours;

forming a positive, active manganese bismuth mixed metal oxide compound having the general formula $MnO_y (Bi_2O_3)_x$, where said subscript x is greater than 0.05 and less than 0.25 and said subscript y is about 2.0;

drying said compound; and

forming ~~a~~ said cathode by mixing said compound with a conductive carbon and a binder~~;~~

~~inserting said cathode into said lithium electrochemical system;~~

~~providing a reduced charge transfer impedance due to a catalytic reaction causing said cathode to prevent an overcharge and a phase change; and~~

~~said compound remaining reversible against a lithium compound in said lithium electrochemical system~~.

54. (Currently Amended) The method of making the manganese mixed metal oxide cathode ~~for a lithium electrochemical system~~, as recited in claim 53, further comprising the step of combining said compound, said carbon and said binder in a 87:9:4 weight percent.

55. (Currently Amended) The method of making the manganese mixed metal oxide cathode ~~material for a lithium electrochemical system~~, as recited in claim 54, wherein said compound results from a solid-state reaction between manganese dioxide~~,~~ and said bismuth compound.

56. (Canceled) The method of making cathode material for a lithium electrochemical system, as recited in claim 55, further comprising the step of providing an initial specific capacity of about 150 mAhrs/g.

57. (Canceled) The method of making cathode material for a lithium electrochemical system, as recited in claim 56, further comprising the step of providing a sustained specific capacity of about 120 mAhrs/g

58. (Currently Amended) The method of making the manganese mixed metal oxide cathode ~~material for a lithium electrochemical system~~, as recited in claim ~~57~~ 55, wherein said subscript x ~~being~~ is greater than 0.05 and less than 0.135.

59. (Currently Amended) The method of making the manganese mixed metal oxide cathode ~~material for a lithium electrochemical system~~, as recited in claim 58, wherein said compound is $MnO_2 (Bi_2O_3)_{0.12}$.

60. (Currently Amended) The method of making the manganese mixed metal oxide cathode ~~material for a lithium electrochemical system~~, as recited in claim 59, further comprising the step of providing a fully reversible compound.

61. (Canceled) The method of making cathode material for a lithium electrochemical system, as recited in claim 60, further comprising the step of providing a fully rechargeable system.

62. (Canceled) The method of making cathode material for a lithium electrochemical system, as recited in claim 61, further comprising the step of maintaining said initial specific capacity with 2/3 of an initial discharge capacity through 100 cycles, said system having a coulombic efficiency greater than 97 per cent and said system having a 95 per cent energy efficient charge.

63. (Canceled) The method of making cathode material for a lithium electrochemical system, as recited in claim 62, further comprising the steps of:

providing said solid-state reaction with the formula $Li + MnO_y (Bi_2O_3)_x = Li_z MnO_y$

$(Bi_2O_3)_x$ where said subscript z approaches 0.0 in said solid-state reaction.

avoiding an overcharge protection is avoided; and

providing a charge transfer catalytic behavior allowing said cathode material to be fully reversible.

64. (Canceled) The method of making cathode material for a lithium electrochemical system, as recited in claim 63, wherein said system is a lithium ion electrochemical system.